each end with a disc of quartz, and through which water was kept circulating to absorb heat rays. The slide on which the hanging-drop cover slip was placed was made of quartz to avoid interception of the ultra-violet rays. The hanging drop thus mounted was then placed on this water-circulating apparatus and the light from the arc was projected through from below upwards, so as to pass through the water and the quartz slide on to the hanging drop.

We have been unable to find that any of the radiations contained in the spectrum are penetrative to organic substances such as agar, or dead animal or vegetable tissue. Neither can they penetrate living tissues, but we are continuing experiments in this direction to more exactly determine their action.

The conclusion to be drawn, therefore, is that the bactericidal action of light is almost entirely due to the action of those radiations in the ultra-violet region of the spectrum which are included between the wave-lengths 3287 and 2265. It is, therefore, necessary that any source of light used as a bactericidal agent should be rich in these rays.

"On the Propagation of Tremors over the Surface of an Elastic Solid." By HORACE LAMB, F.R.S. Received June 11,—Read June 11, 1903.

(Abstract.)

The paper treats of the propagation of vibrations over the surface of a "semi-infinite" isotropic elastic solid, *i.e.*, a solid bounded only by a plane. For purposes of description, this plane may be conceived as horizontal and the solid as lying below it, although gravity is not specially taken into account.

The vibrations are supposed due to an arbitrary application of force at a point. In the problem most fully discussed this force consists of an impulse applied normally to the surface; but some other cases, including that of an internal source of disturbance, are also (more briefly) considered. Owing to the complexity of the problem, attention has been concentrated for the present on the vibrations as they manifest themselves at the free surface; the modifications which the latter introduces into the character of the waves propagated into the interior have accordingly not been examined minutely.

The investigation may perhaps claim some interest on theoretical grounds, and also in relation to the phenomena of earthquakes. Writers on seismology have naturally endeavoured, from time to time, to interpret the phenomena, at all events in their broader features, by the light of elastic theory. Most of these attempts have been based

on the general laws of wave-propagation in an unlimited medium, as developed by Green and Stokes; but Lord Rayleigh's discovery* of a special type of surface-waves has made it evident that the influence of the free surface in modifying the character of the vibrations is more definite, and more serious, than had been suspected. The present memoir seeks to take a further step in the adaptation of the theory to the actual conditions, by investigating cases of *forced* waves, and by abandoning (ultimately) the restriction to simple-harmonic vibrations. Although the circumstances of actual earthquakes must differ greatly from the highly idealised state of things which we are obliged to assume as a basis of calculation, it is hoped that the solution of the problems here considered may not be altogether irrelevant.

It is found that the surface disturbance produced by a single impulse of short duration may be analysed roughly into two parts, which we may distinguish as the "minor tremor" and the "main shock," respectively. The minor tremor sets in at any place, with some abruptness, after an interval equal to the time which a wave of longitudinal displacement (in an unlimited medium) would take to traverse the distance from the source. Except for certain marked features at the inception, and again (to a lesser extent) at an epoch corresponding to that of direct arrival of transversal waves, it may be described, in general terms, as consisting of a long undulation leading up to the main shock, and dying out gradually after this has passed. Its time-scale is more and more protracted, and its amplitude more and more diminished, the greater the distance from the source. The main shock, on the other hand, is propagated as a solitary wave (with one maximum and one minimum, in both the horizontal and vertical displacements); its time-scale is constant, and its amplitude diminishes only in accordance with the usual law of annular divergence, so that its total energy, unlike that of the minor tremor, is maintained undiminished. Its velocity is that of free Rayleigh waves, and is accordingly somewhat less than that of waves of transversal displacement in an unlimited medium.†

The paper includes a number of subsidiary results. The various problems are attacked, in the first instance, in their two-dimensional forms. The interpretation of the analytical results is then com-

* 'Lond. Math. Soc. Proc.,' vol. 17, p. 4 (1885); 'Scientific Papers,' vol. 2, p. 441.

† Compare the concluding passage of Lord Rayleigh's paper:

"It is not improbable that the surface-waves here investigated play an important part in earthquakes and in the collision of elastic solids. Diverging in two dimensions only, they must acquire at a great distance from the source a continually increasing preponderance."

The calculations show that the preponderance is much greater than would be inferred from a mere comparison of the ordinary laws of two-dimensional and three-dimensional divergence.

paratively easy; and it is found that a good deal of the work can be utilised afterwards in the transition to the three-dimensional cases. Again, the investigation of a simple-harmonic source of disturbance is a natural preliminary to that of a source varying according to an arbitrary law.

Incidentally, new solutions are given of the well-known problems where a periodic force acts transversally to a line, or at a point, in an unlimited solid. These serve, to some extent, as tests of the analytical method, which presents some features of intricacy.

"Some Preliminary Observations on the Assimilation of Carbon Monoxide by Green Plants." By W. B. Bottomley, Professor of Botany, King's College, London, and Herbert Jackson, Assistant Professor of Chemistry, King's College, London. Communicated by Professor J. Reynolds Green, Sc.D., F.R.S. Received June 11,—Read June 18, 1903.

During an investigation by one of us some years ago on "Carbon Monoxide in some of its Physiological Effects," a few experiments were made on plants, and it was noticed that a hyacinth, which had commenced growth and was showing a few small leaves, continued to grow for some weeks when placed in a bell jar in which the air had been replaced by a mixture of 80 per cent. of carbon monoxide and 20 per cent. of oxygen. As this was contrary to the usually accepted ideas as to growth of green plants in carbon monoxide, a number of experiments were recently commenced with a view to determining how far carbon monoxide could replace carbon dioxide as a source of carbon supply for green plants. Although the hyacinth grew in carbon monoxide the experiment was not considered conclusive, because of the large stores of carbohydrates in the bulb. Young plants of *Tropæolum majus*, grown in sterilised sand and supplied with a nutritive solution free from all traces of carbonates, were therefore used. It was found that *Tropæolum* plants would not grow in air in which the carbon dioxide had been replaced by an equal quantity of carbon monoxide. When, however, the relative solubilities of the two oxides of carbon in water were taken into account, and the amount of carbon monoxide was increased proportionately—about twenty times as much carbon monoxide as carbon dioxide—the plants grew well, being healthy and normal. Experiments were also made with varying proportions of carbon monoxide in air free from all traces of carbon dioxide. The plants grew freely and well in proportions varying from 1 to 70 per cent. of carbon monoxide, when care was taken that as the higher percentages of carbon monoxide